Analysis of FOOD TEXTURE

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Texture comprises those properties of a foodstuff, apprehended by the eyes and by the and muscle senses in the mouth, including roughness, smoothness, graininess, etc.

(Anonymous, 1964)
What is Texture?

Texture is the attribute of a substance resulting from a combination of physical properties and perceived by the senses of touch, sight, and hearing.

Physical properties may include size, shape, number, nature, and conformation of constituent structural elements

(Jowitt, 1974)

What is Texture?

Texture is the human physiological-psychological perception of a number of rheological and other properties of foods and their interactions

(McCarthy, 1987)
What is Texture?

- Physical properties derived from food structure
- **Group of mechanical and/or rheological properties** → sensed by touch, usually in mouth
- Not a chemical senses (taste/odor)
  - Objective measurement through force \([MLT^{-2}]\), work \([ML^2T^{-2}]\), and flow \([L^3T^{-1}]\)
  - “Texture” usually applies to solids;
  - “Viscosity” to liquids.

Texture is associated with …

- Food rheology
- Other physical properties: wettability, phase changes, surface tension
- Sensory science
- Mastication/anatomy/physiology
Texture is associated with …

• But
  → Rheology and mechanical properties are not texture
  → Empirical tests may do a better job of predicting texture as perceived by panelists

“The fact that fundamental rheological measurements may not correlate as well with sensory measurements of texture as do empirical tests may result from the incompleteness of the science of rheology to describe all the changes that are actually sensed in the mouth”

Malcolm Bourne (1982)
The importance of Texture:

- **Critical** -- food in which texture is the dominant quality characteristic (meat, celery, chips)

- **Important** -- foods in which texture is significant but not dominant (fruit, bread, candy)
The importance of Texture:
- Minor -- foods in which texture makes a negligible contribution (beverages, thin soups)

Texture: Parameters & nomenclature

<table>
<thead>
<tr>
<th>Mechanical Characteristic</th>
<th>Secondary Parameter</th>
<th>Popular Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>Brittleness</td>
<td>Soft-firm-hard</td>
</tr>
<tr>
<td>Cohesiveness</td>
<td>Chewiness</td>
<td>Crumbly Crunchy</td>
</tr>
<tr>
<td>Gumminess</td>
<td>Chewiness</td>
<td>Brittle</td>
</tr>
<tr>
<td>Chewines</td>
<td>Chewiness</td>
<td>Tender</td>
</tr>
<tr>
<td>Viscosity</td>
<td>Chewy</td>
<td>Chewy</td>
</tr>
<tr>
<td>Elasticity</td>
<td>Tough</td>
<td>Tough</td>
</tr>
<tr>
<td>Adhesiveness</td>
<td>Thin-viscous</td>
<td>Thin-viscous</td>
</tr>
<tr>
<td></td>
<td>Plastic-elastic</td>
<td>Plastic-elastic</td>
</tr>
<tr>
<td></td>
<td>Sticky-tacky-gooey</td>
<td>Sticky-tacky-gooey</td>
</tr>
</tbody>
</table>
### Geometrical Characteristic

<table>
<thead>
<tr>
<th>Particle size/shape</th>
<th>Gritty, grainy, coarse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle shape and orientation</td>
<td>Fibrous, cellular, crystalline</td>
</tr>
</tbody>
</table>

### Other Characteristics

<table>
<thead>
<tr>
<th>Secondary Parameter</th>
<th>Poplar Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content</td>
<td>Dry - moist - wet - watery</td>
</tr>
<tr>
<td>Fat content</td>
<td>Oiliness</td>
</tr>
<tr>
<td></td>
<td>Oily</td>
</tr>
<tr>
<td></td>
<td>Greasiness</td>
</tr>
<tr>
<td></td>
<td>Greasy</td>
</tr>
</tbody>
</table>
Texture Analyzers

• A variety of lab instruments exist that carefully control distance and measure force while probing a food sample
• These instruments can be fitted with a wide variety of probes and fixtures
Texture Analyzers

- LFRA Texture Analyzer

- Stable Micro Systems, TA XT2, TA XHD
Texture Analyzers

• Stable Micro Systems, TA XT2, TA XHD -- probes

Texture Analyzers

• Instron
Texture Analyzers

→ Typically, these devices measure force as the probe is lowered or raised

Texture Analyzers

• Compression test

  • A flat probe is lowered on the sample
  • Sample is contained within area of probe
  • Measure maximum force, force to break or work (sometimes distance) to break used as measure of firmness or hardness
  • Examples: carrot cylinders, cake, gels, rice, bread rolls
Texture Analyzers
• Compression test

Maximum force at compression, or break point

Force

Distance
Texture Analyzers
• Compression test

Work is area under the curve

\[ W = \int F \, dx \]
Texture Analyzers

• Penetration test → penetrometer

• Smaller cylinder is pushed into sample
• Maximum force to reach specified distance; force at yield point; mean plateau force
• Apples, cookies, bread, caramel, cherries, fish, fondant, gels, ice cream, peppers, surimi
• Probe may be cylinder, cone, or ball
Texture Analyzers

- Penetration test → penetrometer

Cone Penetrometer Probes
Texture Analyzers

- Penetration test → penetrometer

- Measure force required to snap a rigid food sample
- Knife edge lowered to a thin food across a bending platform
- Bending force generated until material snaps
- Biscuits, cookies, carrot, chewing gum, crackers, dry lasagne, pretzels
- Used with snack chips, thin crisp items
Texture Analyzers
- Snapping test
Texture Analyzers

• Extrusion test

- Force applied to sample until it flows through slots, holes, or annular spaces
- Maximum force to extrude product is measure of firmness or tenderness
- Viscous materials including some gels, fats, peas, catsup

Texture Analyzers

• Extrusion test – Back extrusion
  - FMC Pea Tenderometer

Material compresses

Material begins to be extruded through annular ring
Texture Analyzers
• Extrusion test – *Back extrusion*
  - FMC Pea Tenderometer

A-B peas deformed and packed more tightly
B peas packed solid; liquid begins to be expressed and fill spaces
B-C force increases as juice is expressed
C-D peas rupture and flow through annulus
Texture Analyzers

- Extrusion test – **Back extrusion**

- Extrusion Test – **Forward Extrusion:**
  → force material through a hole
Texture Analyzers:

- Extrusion Test – Forward Extrusion:  
  ➔ force material through a hole

Forward extrusion:  
Baking fats, ketchup

TEXTURE PROFILE ANALYSIS (TPA)
TEXTURE PROFILE ANALYSIS

• Attempt to correlate instrumental measurements with sensory descriptions
• First developed by Friedman; Szczesniak (1963) at the General Foods Corporation: General Foods Texturometer
• Modified by Malcolm Bourne for the Instron

Illustration: Bite-sized food compressed 2 times to simulate chewing
• ~1 cm³ (bite size pieces) compressed (and decompressed) 2 times
• Develop plot of force vs. time
TEXTURE PROFILE ANALYSIS

• Illustration: Bite-sized food compressed 2 times to simulate chewing

→ plot of force vs. time
TEXTURE PROFILE ANALYSIS

- **Definition**
  - *Fractuability*: force required to produce first significant break in the curve on the first bite.
  - Popular terms: crumbly, crunchy, brittle

- **Hardness**: force exhibited in first bite at maximum compression
- Popular terms: soft, firm, hard
TEXTURE PROFILE ANALYSIS

- Definition

- **Cohesiveness**: Ratio of the positive force areas under first and second compressions \( \frac{A_2}{A_1} \); Usually use only areas under the compression part of curve (not decompression) \( \rightarrow \) see Figure.

![Graph showing force vs. time with areas labeled A1 and A2 for cohesiveness](image)

- **Adhesiveness**: work to pull the plunger away from the sample after the first compression \( A_3 \)

- Popular terms: sticky, tacky, gooey

![Graph showing force vs. time with areas labeled A1, A2, and A3 for adhesiveness](image)
TEXTURE PROFILE ANALYSIS

- **Definition**
  - **Springiness**: Distance over which the material recovers its height between the end of the first bite and the start of the second bite ($L_2$)
  - Popular terms: plastic, elastic

![Graph showing force over time with definitions and measurements](image)

- **Springiness** sometimes defined as by a ratio $L_2/L_1$
TEXTURE PROFILE ANALYSIS
- **Definition**
  - **Stringiness**: the distance that the product is extended during decompression before separating from the probe.

  ![Diagram](image1.png)

  - **Resilience**: A measurement of how the sample recovers from deformation. \( \frac{A_5}{A_1} \)
  - Ratio of the first UP (decompression) stroke to the first DOWN (compression) stroke

  ![Diagram](image2.png)
TEXTURE PROFILE ANALYSIS

- Definition
  - Gumminess: hardness X cohesiveness
  - Popular terms: short, mealy, pasty, gummy
  - Chewiness: gumminess X springiness

→ Gumminess and chewiness are not reported for the same food!

More... read:

1. An Overview of Texture Profile Analysis (TPA)
   (http://texturetechnologies.com/texture-profile-analysis/texture-profile-analysis.php)
2. Texture Profile Analysis Explained & Annotated
   (http://128.121.92.221/texture_profile_analysis.html)

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